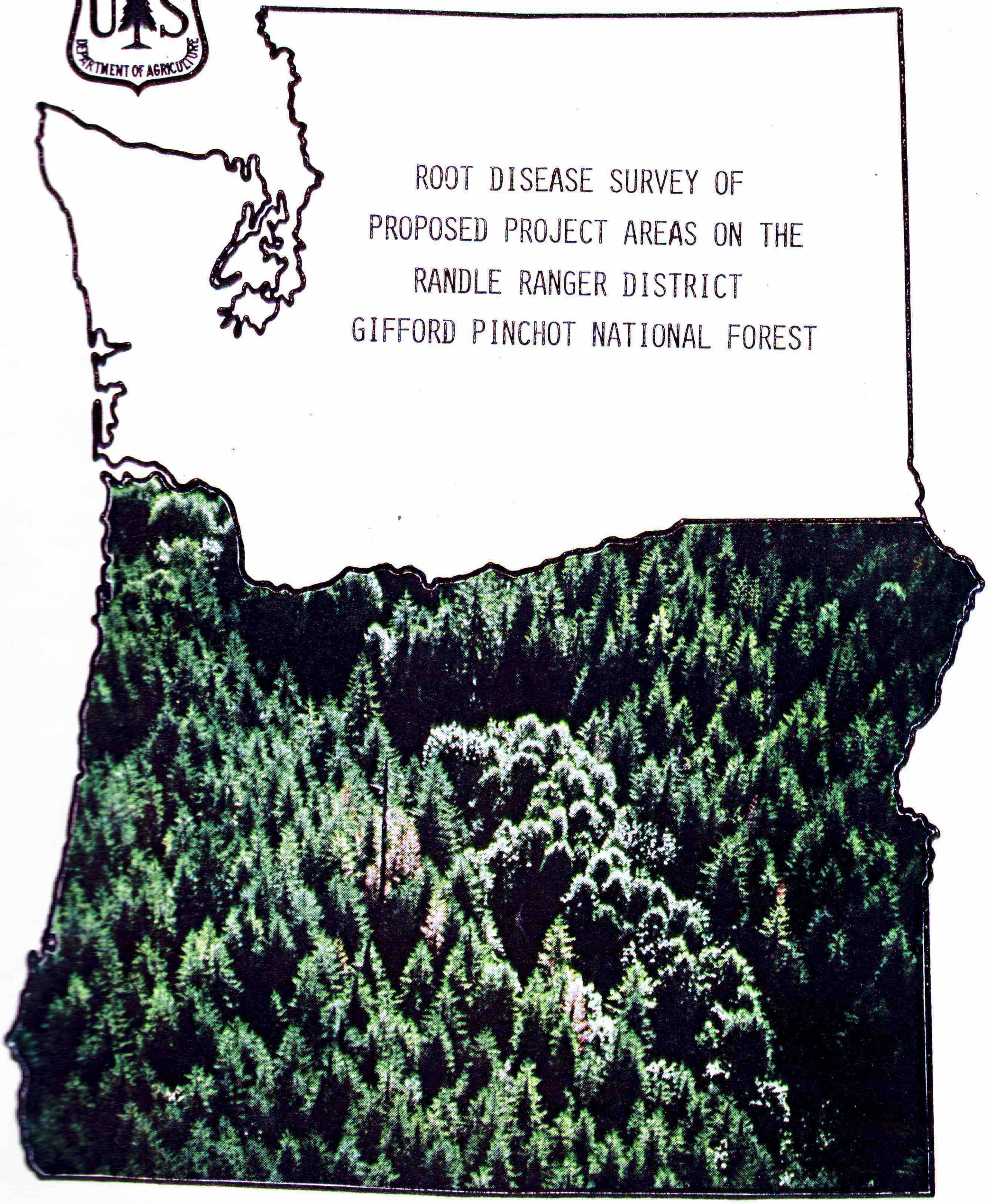
Forest Pest Management
Pacific Northwest Region

FOREST SERVICE
U S
DEPARTMENT OF AGRICULTURE

ROOT DISEASE SURVEY OF
PROPOSED PROJECT AREAS ON THE
RANDLE RANGER DISTRICT
GIFFORD PINCHOT NATIONAL FOREST



Prepared by Robert D. Harvey

ROBERT D. HARVEY, JR. Plant Pathologist

12/13/84

Date

Prepared by Ellen Michaels Goheen

ELLEN MICHAELS GOHEEN, Biological Techn.

12/13/84

Date

Prepared by Daniel A. Dunham

DANIEL A. DUNHAM, Biological Techn.

12/13/84

Date

Reviewed by James S. Hadfield

JAMES S. HADFIELD, Group Leader

12/14/84

Date

Approved by Paul E. Buffam

PAUL E. BUFFAM, Director of Forest Pest Management

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by

Robert D. Harvey, Jr., Pathologist
Ellen Michaels Goheen, Biological Technician
Daniel A. Dunham, Biological Technician
Forest Pest Management
Pacific Northwest Region
USDA Forest Service

ACKNOWLEDGMENT

The authors extend their appreciation to Gregory M. Filip, Craig L. Schmitt, John W. Hazard, and Gary Wright for their assistance and support in accomplishing this survey.

ABSTRACT

A two-stage root disease sampling system including aerial and ground survey techniques was used on 60-year-old stands of primarily Douglas-fir. While we were expecting aerial survey with supplemental ground sampling to provide us with information on the location and amount of root disease present, this did not turn out to be the case. Aerial survey did not prove to be effective in consistently detecting root disease in these stands; however, ground survey of nearly 20.2 miles of transects revealed more than 33 percent of the 16,300 acres to be infected. Land managers should have individual units surveyed for root disease prior to planned entries.

INTRODUCTION

During the early part of 1984, personnel of the Randle RD, Gifford Pinchot NF, contacted Forest Pest Management (FPM) with a request for a survey to detect root disease over a total of approximately 16,300 acres of proposed project area that would be entered for thinning within the next 10 years. The area of concern had been burned about 60 years ago and is generally composed of Douglas-fir stands of that age. For some, the future proposed entry would be the second, but for most it would be the first. Forest management plans require that knowledge of forest pests be considered for future entries and, since there was local knowledge of scattered root disease in some of the areas, a formal request for survey was made to FPM.

With labor and budgetary limitations in mind, a decision was made to sample the area with a two-stage system using helicopter aerial sketchmap survey techniques followed up by a limited ground sample. With this system, it was expected that the major areas of root disease concern would be delineated with enough accuracy that land managers could develop their plans. In the event that more data were needed, FPM could then do individual surveys of specific sites.

The disease of major concern, laminated root rot caused by Phellinus weirii (Murr.) Gilbertson, is the most damaging root disease in the Pacific Northwest conifer forests. While Douglas-fir is the most important host, nearly all conifers appear to be susceptible to some degree. One of the major problems with P. weirii is that it can remain viable, in large woody pieces, on the site for many years after the death of the host tree, thus making it a disease of the site. In this capacity, it can cause tree mortality and greatly increase the size of current disease centers in future rotations. If the presence of this fungus is ignored and harvest/regeneration is carried out in the normal fashion, land managers are liable to see large increases in growth loss and mortality in subsequent rotations. Plantations will look normal until regeneration reaches 10 to 20 years of age, at which time mortality will start to show up as roots of the new stand begin to make contact with buried inoculum. From this focus, the disease centers can expand outward at a rate of up to 1 foot a year, which could result in a center of 160 to 180 feet in diameter at a stand age of 100.

Direct damage caused by P. weirii is in the form of root decay and subsequent growth reduction, mortality, and windthrow. Indirect damage also can occur in the form of reduced tree vigor which renders the tree more susceptible to other fungal and insect attacks. In the case of bark beetles, for instance, populations that build up in weakened, less vigorous trees can spread to healthy, vigorous trees and cause considerably more damage and loss than the root disease alone would have caused.

Laminated root rot, as the name indicates, is characterized by delamination, or separation of the annual growth rings of the tree. Along with this characteristic, wood decayed by P. weirii also exhibits small (1 x 1/2 mm) pits and setal hyphae. Setal hyphae are very small, sterile hyphae that, when grouped together, appear as reddish-brown whiskers on decayed wood. While other fungi may exhibit one or more of these characteristics, P. weirii is the only common fungus in the Pacific Northwest that exhibits all three.

A second root disease, Armillaria root rot, caused by the fungus Armillaria mellea (Vahl. ex Fr.) Quel., is also of concern as it is the most common conifer root rot in the Pacific Northwest. Armillaria root rot affects virtually all trees and other woody species and causes growth loss, root and butt rot, uprooting, tree killing, and predisposition to insect attack. The fungus survives and grows in old stumps, and spreads by root contacts and grafts, and by rhizomorphs which grow through the soil to infect hosts not contacting an inoculum source directly.

Armillaria root rot is characterized by heavy resin flow at the tree base with whitish mycelial sheets, often shaped like fans, under the bark of roots and lower bole. Rhizomorphs (black or brown shoestring-like structures) are also often present. Early decay appears as a watersoaked area with tiny pockets, while advanced decay is a yellow, stringy rot. Golden yellow mushrooms can often be found growing on the infected material in the fall.

MATERIALS AND METHODS

Unit boundaries were delineated on topographic maps, and aerial resource photographs of 1:24,000 and 1:6,000 scale, for use in navigating in the aircraft as well as locating any disease centers detected during the aerial survey. The aerial portion of the survey was accomplished by using a Bell 206 Jet Ranger and pilot already on contract to the Mt. St. Helens and Randle Ranger Districts. In the front seat, along with the pilot, was a navigator whose sole job was to keep the aircraft in the proper location. Two observers were in the back seat marking locations of mortality centers directly on the resource photography. These centers were characterized by dead and/or living symptomatic trees. An indication of a hole in the canopy was helpful. This hole may have been filled with hardwood species or open. Downed trees or root balls were seldom seen from above; therefore, a root disease hole had to be distinguished from a wet area hole by presence of adjacent symptomatic trees.

Initially, two flight speeds were tried, 40 and 100 miles per hour, at an elevation of about 500 feet above the canopy. While 40 mph might have seemed to be the easiest to work with, neither observer found any advantage to going slow since the opportunity to circle or make repeated passes by an area in question was available. This option was exercised extensively.

Following completion of the aerial mapping, a crew of three people collected ground data. Selection of areas to be ground checked was made by first circumscribing a boundary around clusters of polygons on the photos. Constraints used in delineating clusters were time and topographic. Since statistical design called for the ground sample to incorporate a single transect through the long axis of the cluster, each cluster had to be traversed in a single day. Also, boundaries could not cross unnavigable obstacles such as rivers, cliffs, etc.

Clusters were divided into categories of high and low which referred to probability of finding large amounts of root disease. Since there was no attempt to delineate clusters so that they were all the same size and had the same number of polygons, and it would have been difficult or impossible to do so, random selection could not be based on percentage of cluster comprising polygons. To get around this situation, it was hypothesized that the greater the number of polygons in a given cluster, the greater the probability of having root disease present. Accordingly, five polygons per cluster was arbitrarily set as the division between the high and low strata. Selection was random with replacement. Eight clusters were drawn from the high strata and six from the low on the initial selection. Subsequently, extra clusters were

sampled and some were dropped for various reasons, with the outcome that nine were sampled in the high and five in the low strata. Four areas outside of clusters were also sampled to act as a control or zero strata.

Ground sampling was based on a line intercept method whereby a transect was run through the long axis of the cluster and distance along the line recorded when a disease pocket was entered and again when the pocket was exited. Three people were used for the ground survey, one taking data and running the transect line, and the other two identifying disease centers. Line lengths were determined by use of a string machine. A center was recorded as entered if symptomatic trees were found on both sides of the transect, and exited when no symptomatic trees were found on either side of the transect for a distance of at least 20 yards. At least one infected tree on either side of the transect, within 20 yards of the last, was necessary for continuation of the center.

Data were examined by regression analysis using percent of transect found to be infected as the dependent variable and percent of cluster falling within polygons and number of polygons per cluster as the independent variables.

RESULTS

While we expected a fairly strong correlation between aerial and ground data, Table 1 shows the relationship to be weak. The abundance of disease centers (by previous definition) that were not visible from above makes use of aerial survey unsatisfactory in these stands.

TABLE 1 - Regression analysis of Randle root disease survey data showing best fit and statistics.

VARIABLES REGRESSED	BEST FIT CURVE	STATISTICS
% _P_. weirii / % Polygons	linear	R2 = 0.2196 A = 17.3869 B = 0.6699
% _P_. weirii / Total Polygons	power	R2 = 0.1831 A = 0.9664 B = 0.4765

Table 2 presents survey data by cluster.

TABLE 2 - Total polygons, percent of cluster within polygons, percent of transect infected, time required to survey, total acres, and strata designation of Randle RD root disease clusters.

CLUSTER	TOTAL POLYGONS	PERCENT POLYGONS*	PERCENT P.WEIRII**	SURVEY TIME(HRS)	ACRES	STRATA
1	3	26.04	0.00	1.0	48.32	L
2	17	10.46	42.62	4.0	803.88	H
3	53	14.11	38.02	8.0	1553.79	H
5	13	4.32	10.49	3.0	749.04	H
6	18	14.30	36.40	6.0	632.89	H
10	7	14.22	4.99	2.0	88.29	H
12	34	17.86	14.06	4.5	525.72	H
13	21	6.49	17.40	7.0	844.91	H
16	15	15.71	38.88	6.5	272.28	H
20	3	6.02	34.56	3.0	49.63	L
23	2	29.55	20.00	2.0	24.29	L
24	2	9.34	16.04	2.0	60.76	L
25	10	4.58	21.96	8.0	553.64	H
27	3	41.60	57.04	2.0	19.12	L
CC1	-	-	42.13	5.0	-	C
CC2	-	-	24.89	2.0	-	C
CC3	-	-	31.22	1.5	-	C
CC4	-	-	54.31	2.0	-	C

* Aerial data.
** Ground data.

As can be seen by Table 2, 14 of the original 25 distinctly separate clusters were sampled, and four transects were run in the area not included in clusters. Of the original 17 management units, 15 had some ground sampling done in them. The appendix contains individual maps of administrative units and resource aerial photographs, both with transect lines delineated. In addition to the documented transects, a short line was run through the segment of Tongue K Timber Sale unit that is adjacent to a small lake near the gravel pit. While no data were recorded for this line, it should be noted that no root disease was found.

Table 3 compares strata statistics showing also the acres within clusters that were not sampled.

TABLE 3 - Comparison of strata statistics for Randle root disease ground survey.

	SAMPLED HIGH	LOW	ZERO	UNSAMPLED	TOTAL
Estimated % infected	28.14	21.11	38.14	-	33.18
Standard error	0.0387	0.0800	0.0648	-	0.0374
Yards of transect	28,927	3079	3458	-	35,464
Total acres	6024.44	202.12	8103.99	1969.45	16,300

During the ground survey, it became apparent that there were three distinctive types of root disease centers. The first type was the center that was obvious from above as well as below the level of the canopy. It was characterized by active root infection and spread, and exhibited a distinct hole in the canopy with dead, dying, and symptomatic trees around the periphery. Often windthrown trees with decayed root balls were scattered below. Even when the center was quite small, as little as two or three trees, the evidence indicated an active center. The second type of center was not so apparent. Usually it was not readily discernible from above, yet signs and symptoms were quite obvious from below the canopy. Considerable numbers of downed trees with decayed root balls were evident. However, aggressive activity occurred long enough ago that the canopy appeared to have closed and no obvious hole was apparent. Some symptoms of current infection in standing live trees were discernible, i.e., thin crowns and reduced annual height growth.

The first two types of centers would be readily recognizable by land managers with some background in root disease identification. The third type, however, would be considerably more difficult to spot. This type was characterized by few stumps or downed trees with root balls, widely scattered, and usually overgrown with moss or other flora and/or covered with debris. No obvious signs or symptoms of distress were evident in the residual stand, and only a close examination of old decaying trees and stumps could reveal the presence of _P. weirii_. The only reason for categorizing this type as a disease center was our previous decision that _P. weirii_-infected trees within 20 yards of one another constituted a contiguous center. Whether these were three stages in a root disease cycle, differing degrees of aggressiveness of the same fungus, or different sub species or varieties of the fungus is speculative. At this point, it would seem the former is the most probable explanation; that the third type of infection is actually the last dying remnant of a very large center whose active margin is no longer within the immediate vicinity.

Unfortunately, the recognition that there were three apparent types of centers was not made until late in the ground survey segment; therefore, the different types were not recorded when encountered. Had this been the case, post-survey stratification could have been considered with the possible consequence of a stronger correlation between aerial and ground data.

Appendix Tables A and B provide data developed through this survey. Table A gives data for recreating transects, and Table B provides data on location of root disease centers.

DISCUSSION

Two-stage sampling for root disease using aerial and ground samples has been done in the past with varying results. Goheen and Kanaskie (1983) performed a similar survey on a 30- to 40-year-old Douglas-fir stand near Salem, Oregon, and reported considerable success with the helicopter survey. During their survey, however, they discovered a large amount of black stain root disease, and the laminated root rot that they found was apparently only what we classified as aggressively active. Both of these aspects may have made their identification from the air somewhat easier.

The apparent lack of success of the aerial portion of our two-stage sampling system is becoming more and more understandable with time as others try similar surveys. A recent paper by Wallis and Lee (1984) who surveyed 15-, 40-, and 100-year-old stands using aerial photography showed the poorest success in 40-year-old stands. Their procedures differed somewhat in that they used 1:1500 to 1:15000 color and color-infrared aerial photographs, and photo interpretation. They found that dead or nearly dead trees provided the most useful signature of centers but, while they were associated with nearly all centers in the 15- and 100-year-old strata, they were absent or not distinguishable in 30 to 50 percent of the openings in the 40-year-old strata.

It does not appear that much can be said about our units based on the aerial portion of this survey since with it we were unable to detect much of the infection (Table 1). We can, however, use the data that were collected on the ground since nearly 20.2 miles (35,464 yards) were traversed. By combining the data and weighting them by total acres in each strata, it appears that, on the average, 33.18 percent of the area is infected. Since we do not know the exact status of the three types of centers, however, it would be imprudent to consider them to contain anything but aggressively infective inoculum. While we recognize a difference in apparent aggressiveness in the current stands, there are no data available to indicate that the three will act the same in future stands. We must, therefore, consider all of the inoculum highly infective. Owing to the high percentage of area infected with P. weirii, it would be prudent to consider having FPM pathologists do individual surveys on particular units as they are scheduled for entries.

In view of the large amounts of P. weirii detected and the fact that a commercial thinning is the next planned entry into these units, it is important to take a closer look at each area prior to the initiation of activity. While we know that stands with aggressively active root disease centers are likely to suffer serious loss to blowdown if they are heavily thinned, and we suspect that similar results will occur in and around our type one and two disease centers, we do not know what the result will be in areas with our type three centers. During forthcoming individual root disease surveys in these areas, it will be important to note the type of infection center as well as to do excavation of roots of apparently healthy trees in the type three centers. Excavation will help us determine the risk involved in thinning type three, and might give us some insight into how this type will act in future rotations.

REFERENCES

Goheen, D. J. and A. M. Kanaskie.
1983. Root disease survey, Rocky Top unit, Santiam Management Area, Salem District, Bureau of Land Management. USDA FS Office Rept.

Wallis, G. W. and Y. J. Lee.
1984. Detection of root disease in coastal Douglas-fir stands using large scale 70-mm aerial photography. Can. J. For. Res. 14:523-527.

APPENDIX TABLE A - Distance and heading for ground sample transects on the Randle RD, Gifford Pinchot National Forest.

CLUSTER	APPROACH DISTANCE IN YARDS	APPROACH MAGNETIC BEARING	TRANSECT DISTANCE IN YARDS	TRANSECT MAGNETIC BEARING
1	199	180	150	161
2	90	311	3311	108
3	-	-	4876	270
5	-	-	2612	288
6	64	077	2096	077
10	-	-	782	120
12	644	042	3707	302
13	240	303	3528	286
16	150	180	1635	333
	-	-	1020	012
	-	-	890	329
20	-	-	1020	311
23	-	-	765	080
24	-	-	455	087
25	200	270	4470	175
27	-	-	689	146
CC1	-	-	1614	308
CC2	-	-	655	003
CC3	-	-	679	350
CC4	-	-	510	323

APPENDIX TABLE B - Line intercept data for disease centers, by transect, on the Randle RD, Gifford Pinchot National Forest.

TRANSECT NUMBER	DISEASE CENTER ENTER	EXIT	LENGTH IN YARDS
1	-	-	0
2	30	297	267
	358	402	44
	700	725	25
	89	130	41
	0	50	50
	136	267	131
	668	1541	873
3	341	702	361
	1013	1127	114
	1247	1344	97
	1396	1434	38
	1482	1804	22
	1830	1996	166
	2234	2256	22
	2680	2708	28
	2731	2748	17
	2848	3002	154
	3075	3157	82
	3331	3361	30
	3541	3622	81
	3716	3748	32
	3956	4225	269
	4626	4666	40
	4714	4743	29
	4802	4876	74
5	1229	1248	19
	2269	2385	116
	2421	2461	40
	2499	2598	99
6	84	248	164
	272	496	224
	47	110	63
	249	313	64
	556	622	66
	700	780	80
	862	906	44
	1655	1780	125
10	313	352	39

TRANSECT NUMBER	DISEASE CENTER ENTER	EXIT	LENGTH IN YARDS
12	136	175	39
	824	869	45
	1013	1028	15
	1082	1116	28
	1441	1484	43
	2156	2191	35
	2239	2334	95
	2764	2779	15
	2910	2953	43
	3185	3306	121
	222	242	20
	279	463	184
	595	892	297
	1647	1798	151
	1844	1880	36
	1916	1956	40
16-1	80	114	34
	146	288	142
	446	498	52
	546	588	42
	723	772	49
	804	836	32
	919	1086	167
	1135	1164	29
	1117	1295	178
	1392	1412	20
16-2	61	99	38
	191	689	498
16-3	402	471	69
20	150	294	144
	421	453	32
	700	781	81
	951	1056	105
23	330	390	60
	660	750	90
24	262	335	73
25	425	480	55
	807	930	123
	1118	1217	99
	1650	1681	31*
	1880	1982	102
	2033	2168	135
	2419	2575	156
	3234	3302	68
	3627	3726	99
	4028	4115	87

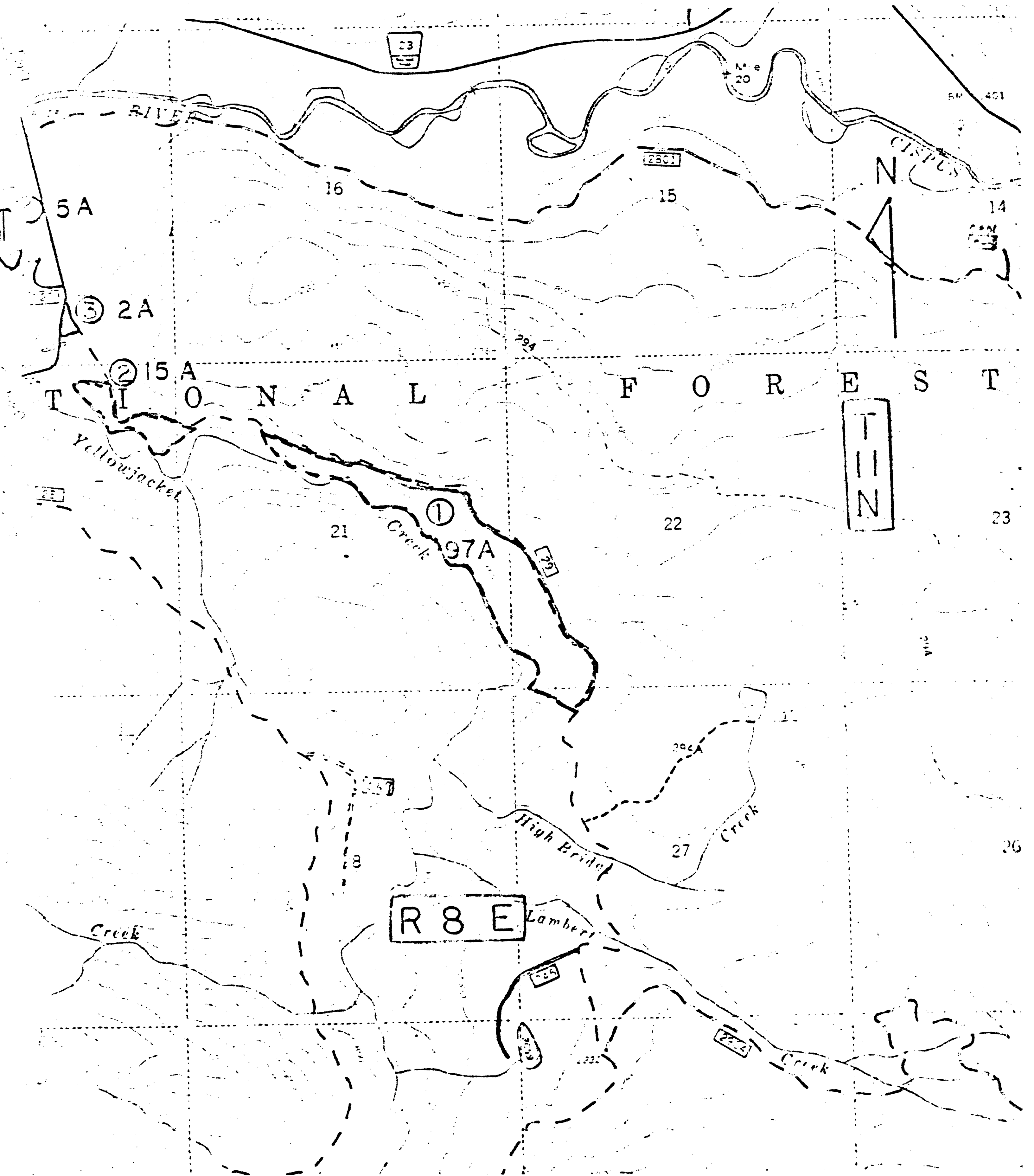
* - Armillaria mellea center

TRANSECT NUMBER	DISEASE CENTER ENTER	DISEASE CENTER EXIT	LENGTH IN YARDS
27	28	325	297
	356	435	79
	507	524	17
CC1	165	300	135
	330	394	64
	437	530	93
	553	568	15
	857	894	37
	1128	1313	185
	1358	1509	151
CC2	44	93	49
	193	307	214
CC3	35	57	22
	325	394	69
	483	604	121
CC4	42	167	125
	210	362	152

TONGUE K TIMBER SALE

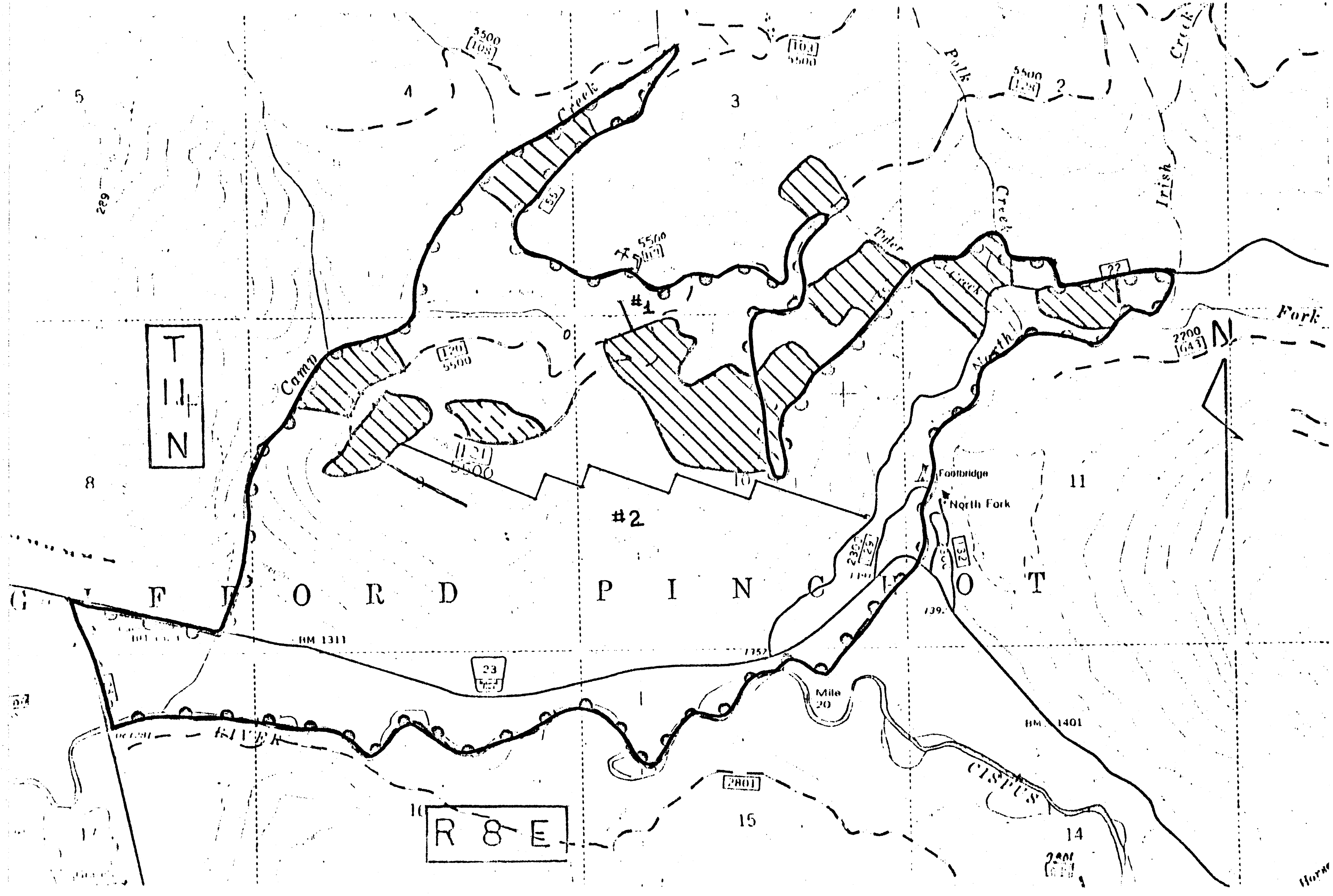
119 A HTH

1986



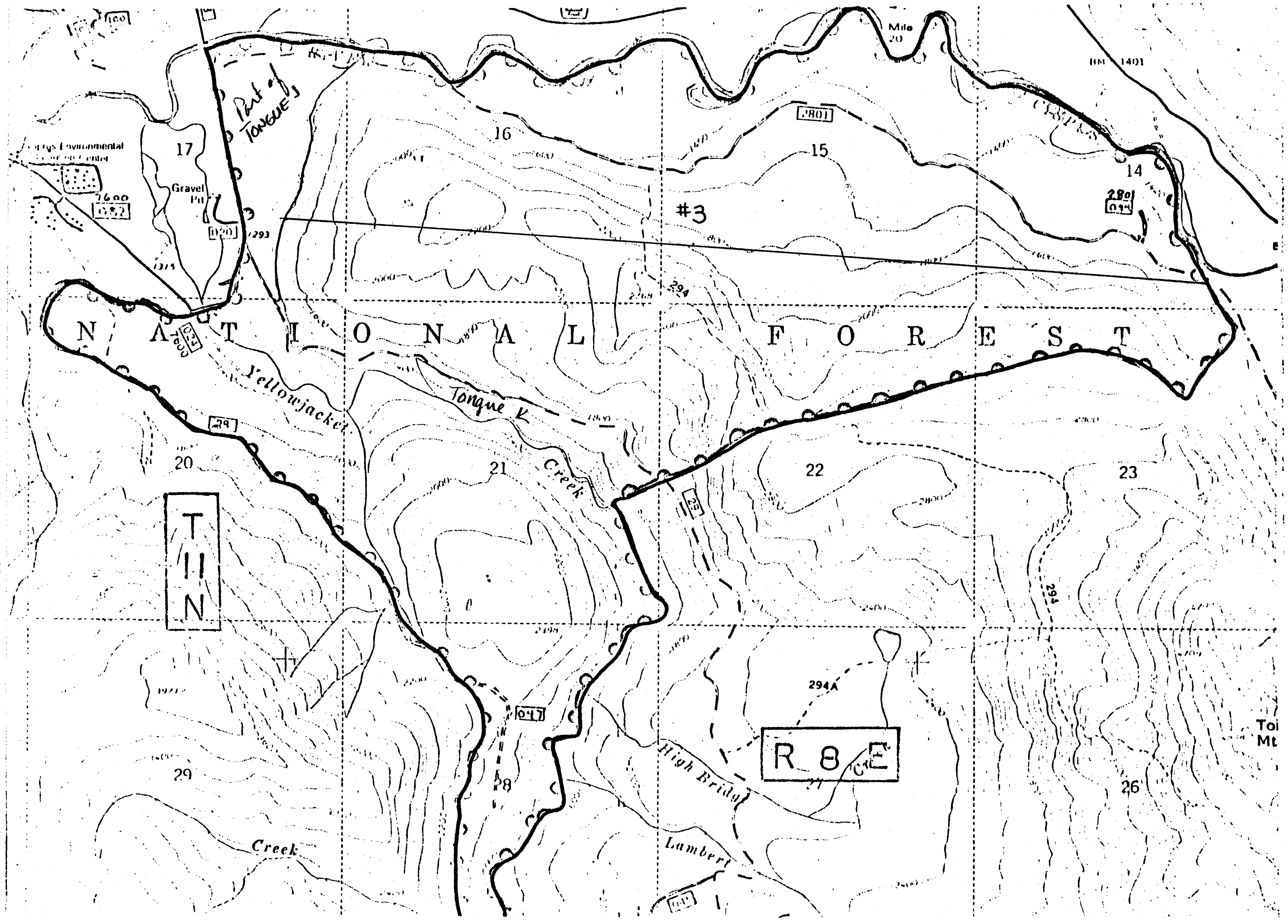
POLK M PROJECT AREA

1989



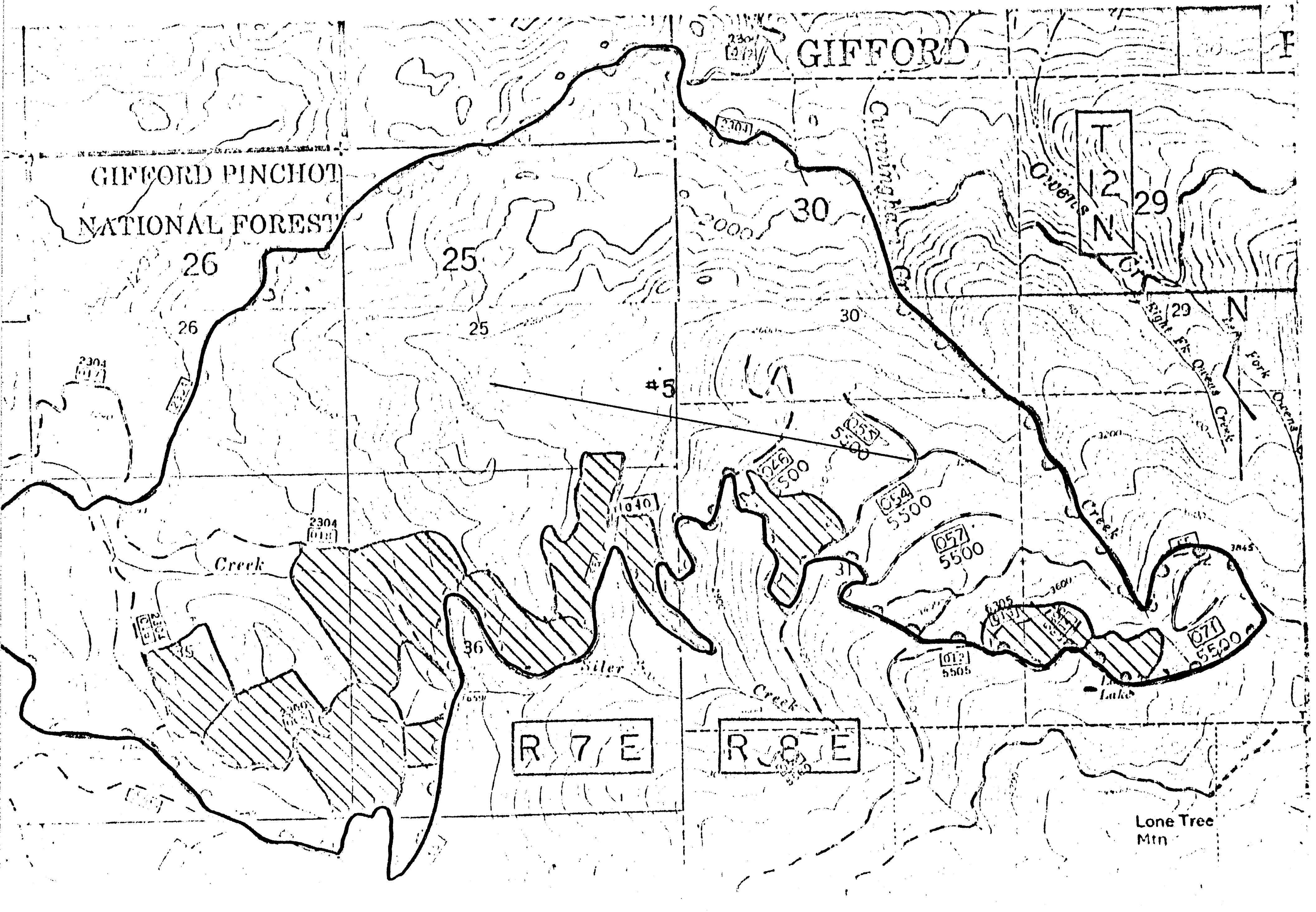
ROCK B PROJECT AREA

1988



SILER P PROJECT AREA

1988



POLK N PROJECT AREA

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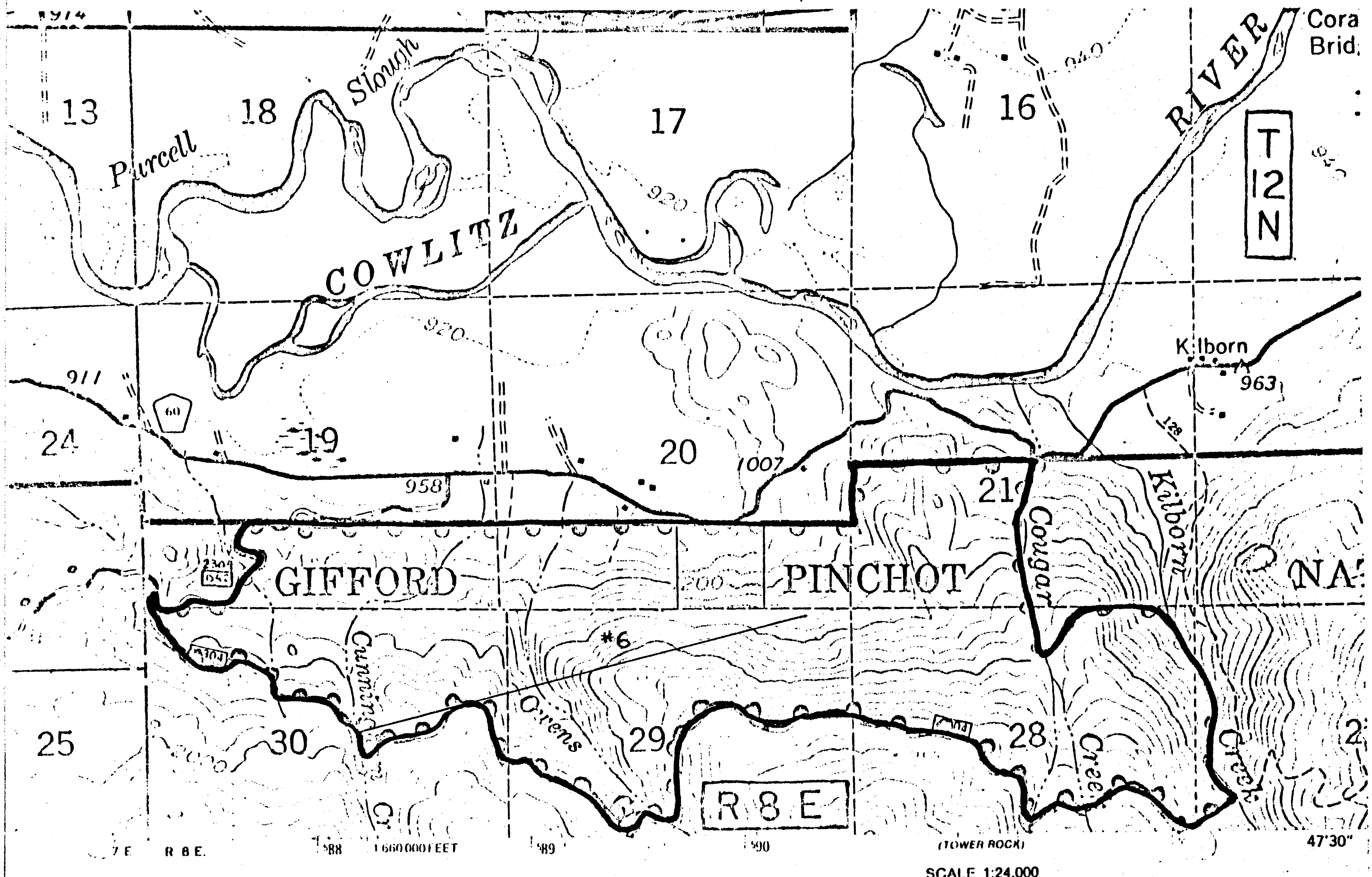
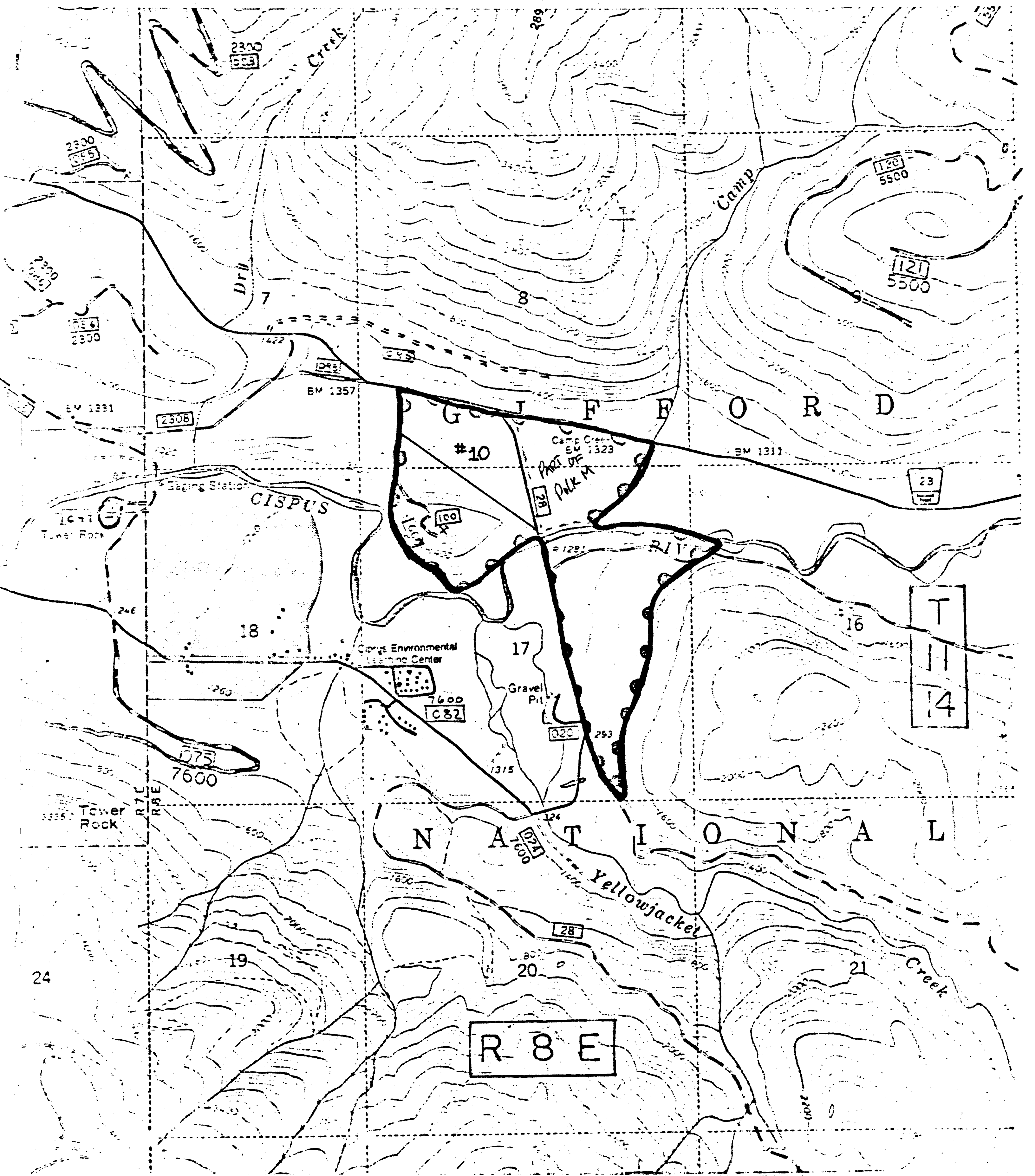
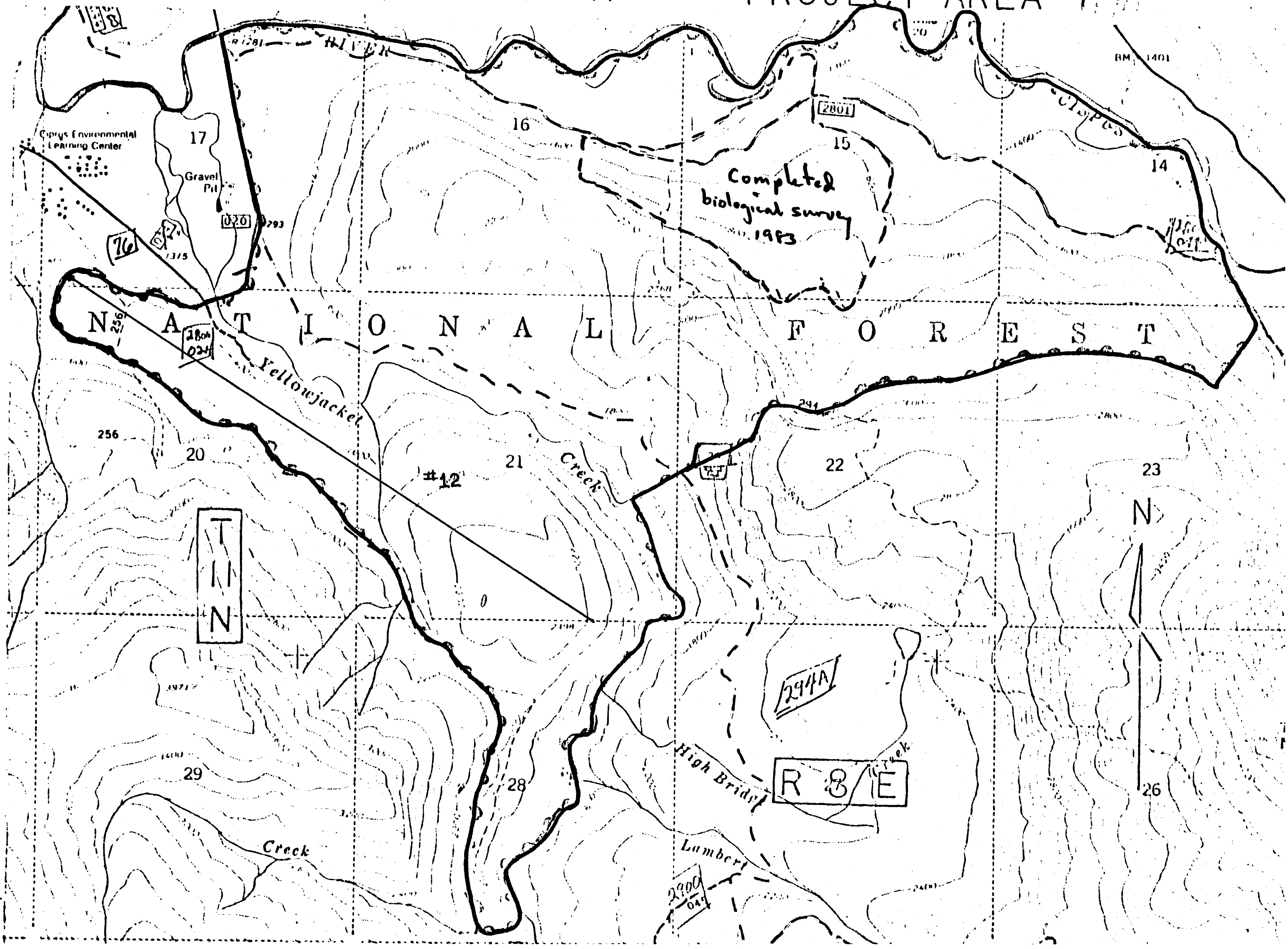


TONGUE J PROJECT AREA

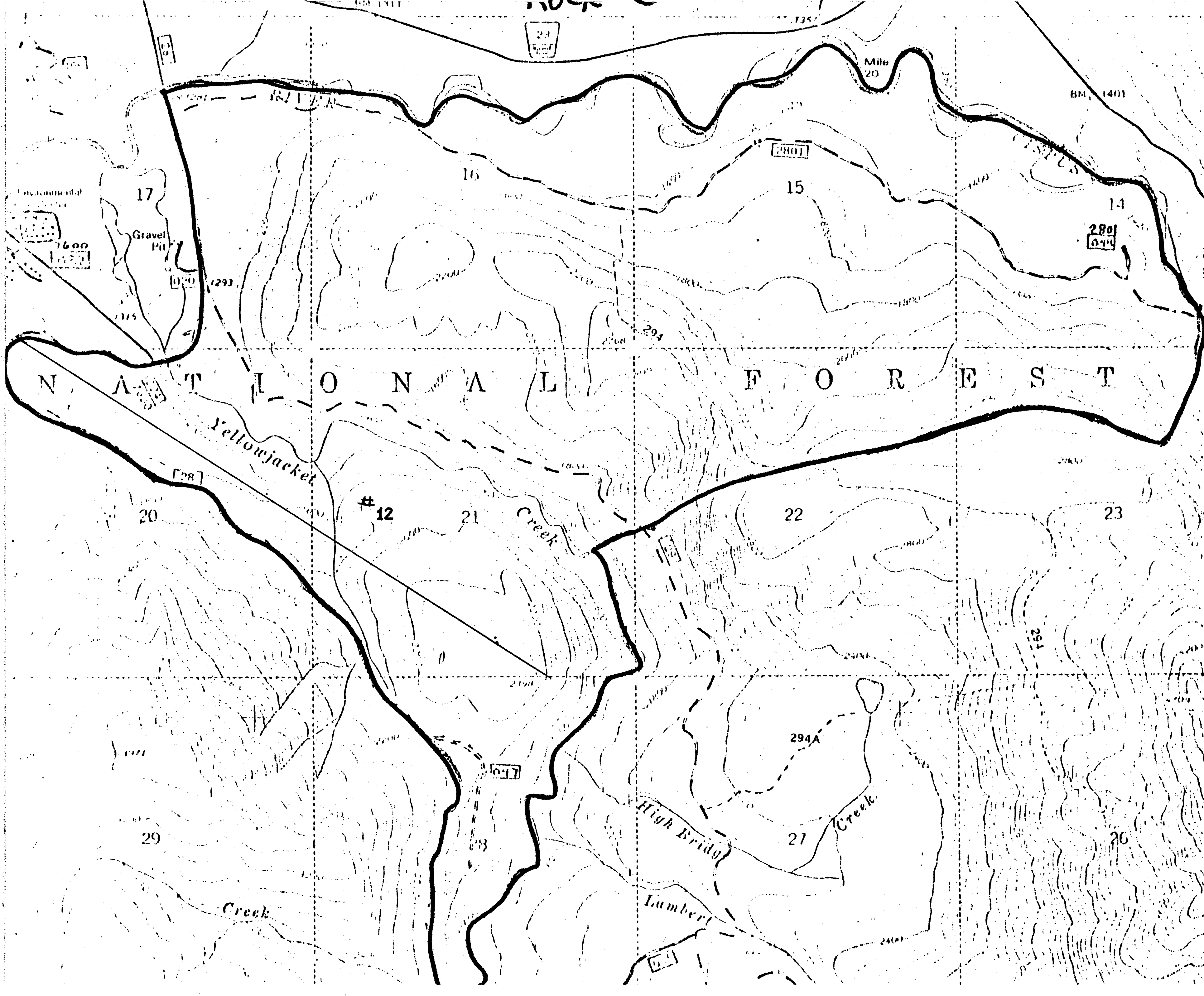
1986



TONGUE H PROJECT AREA



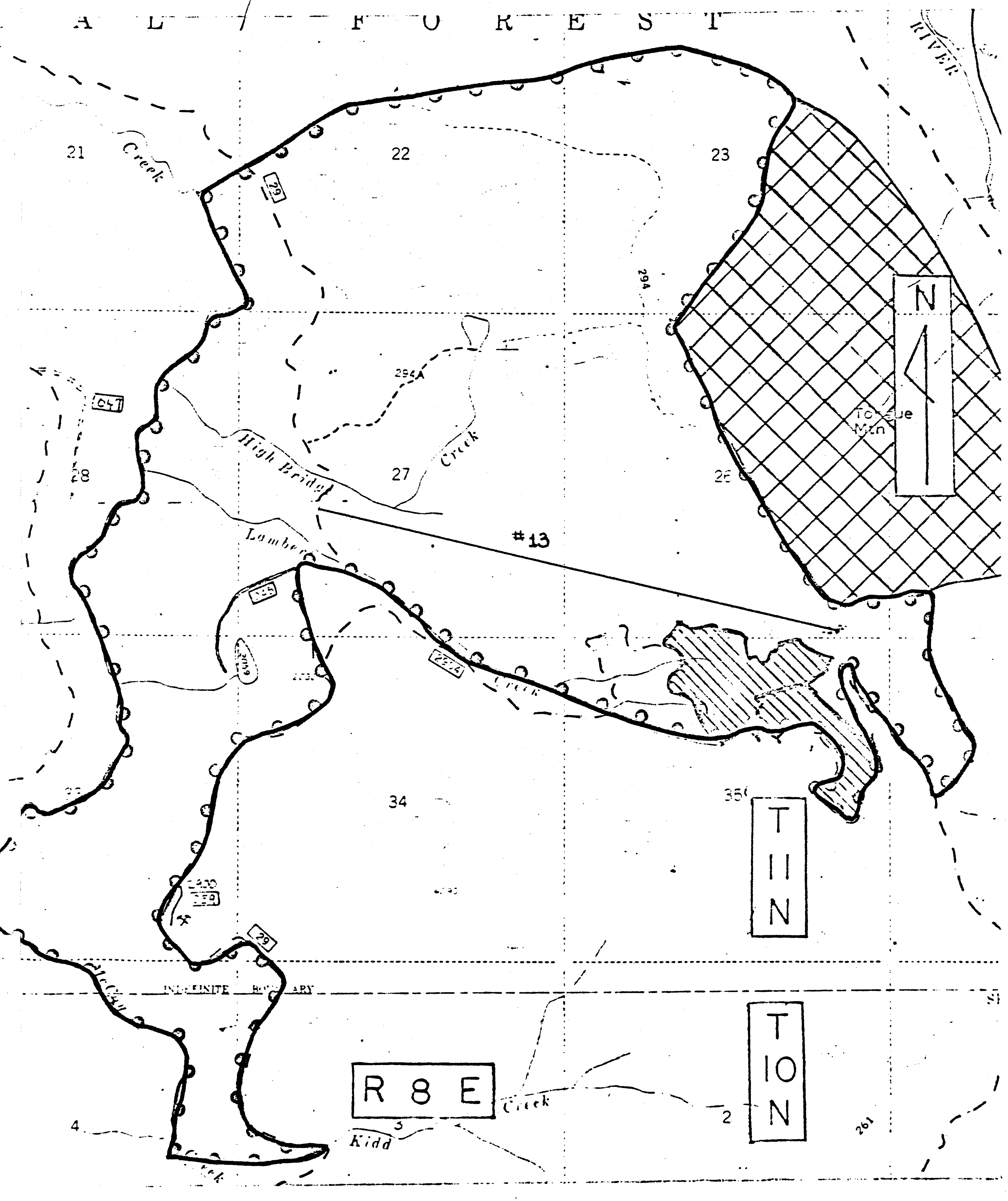
Rock C



Rock C 1992

Tongue E Project Area

1981



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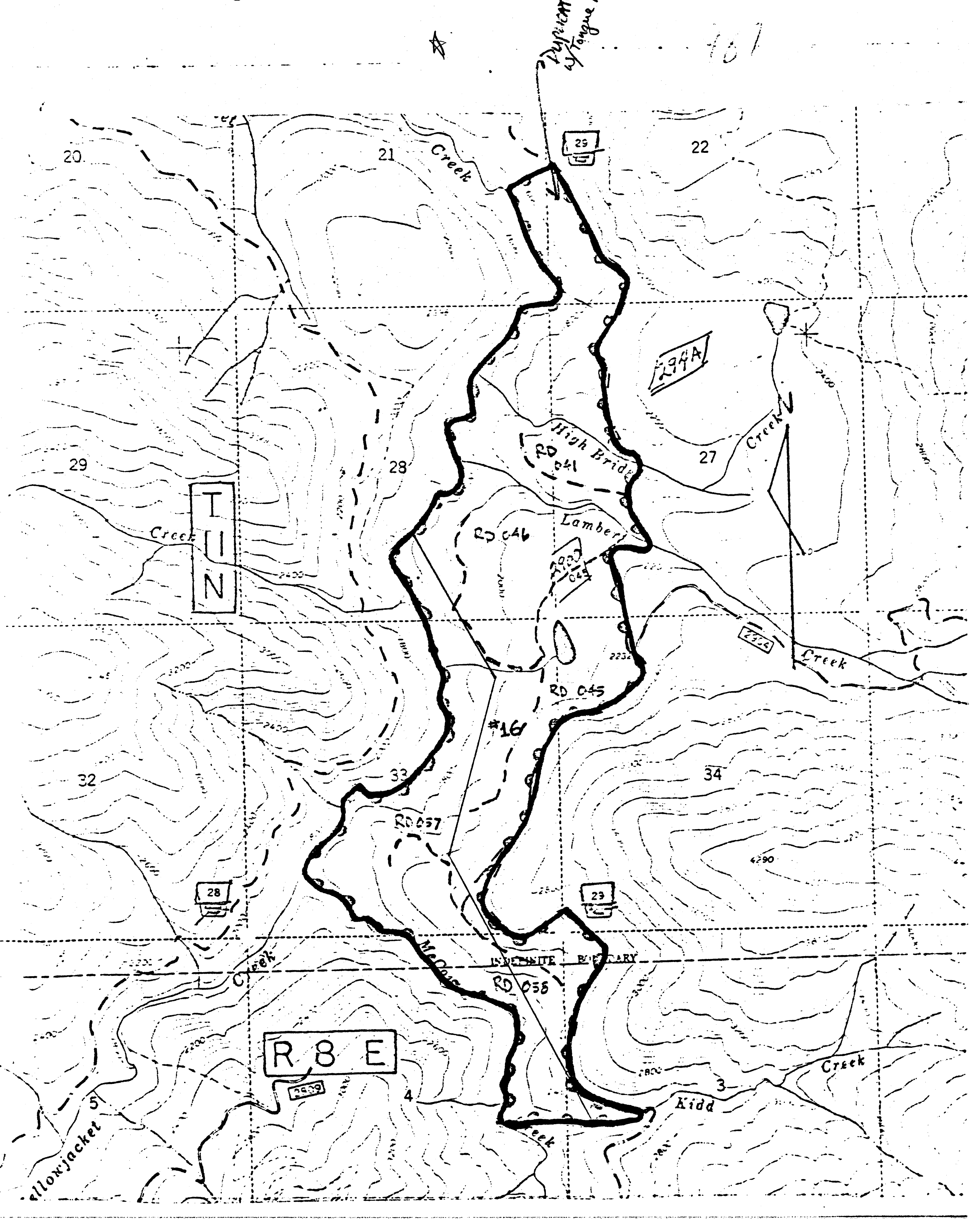
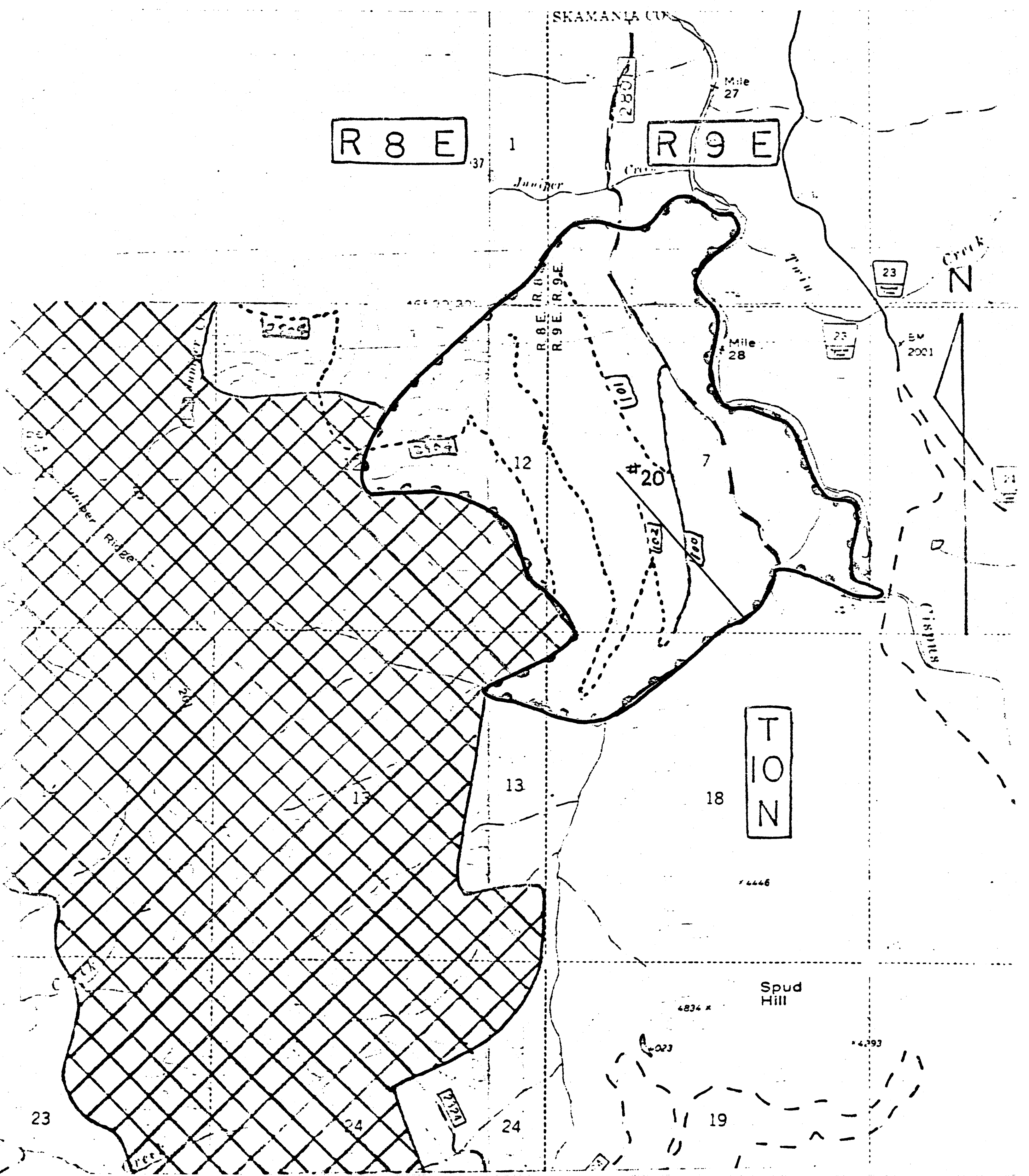


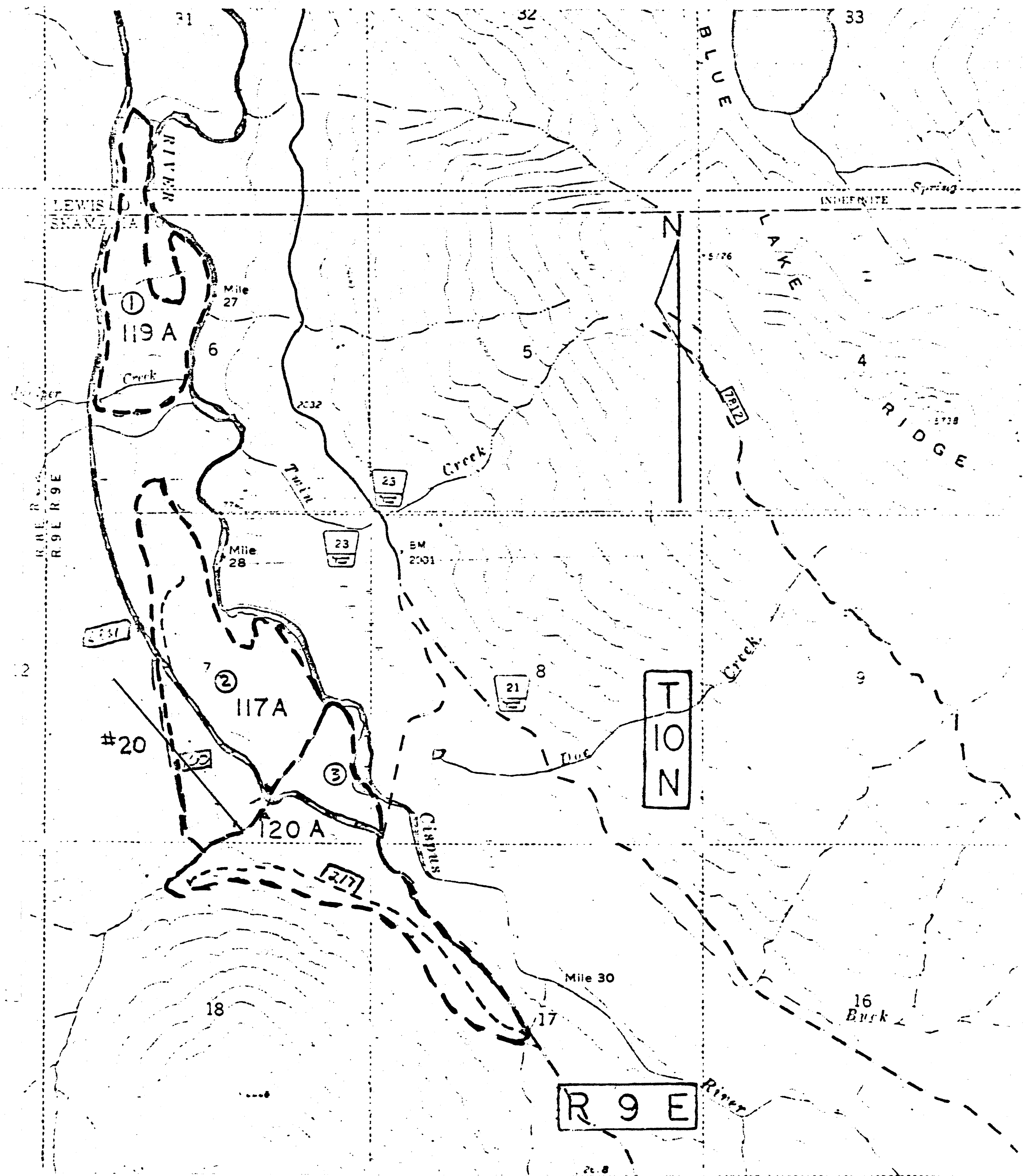
KIDDA PROJECT AREA

1988



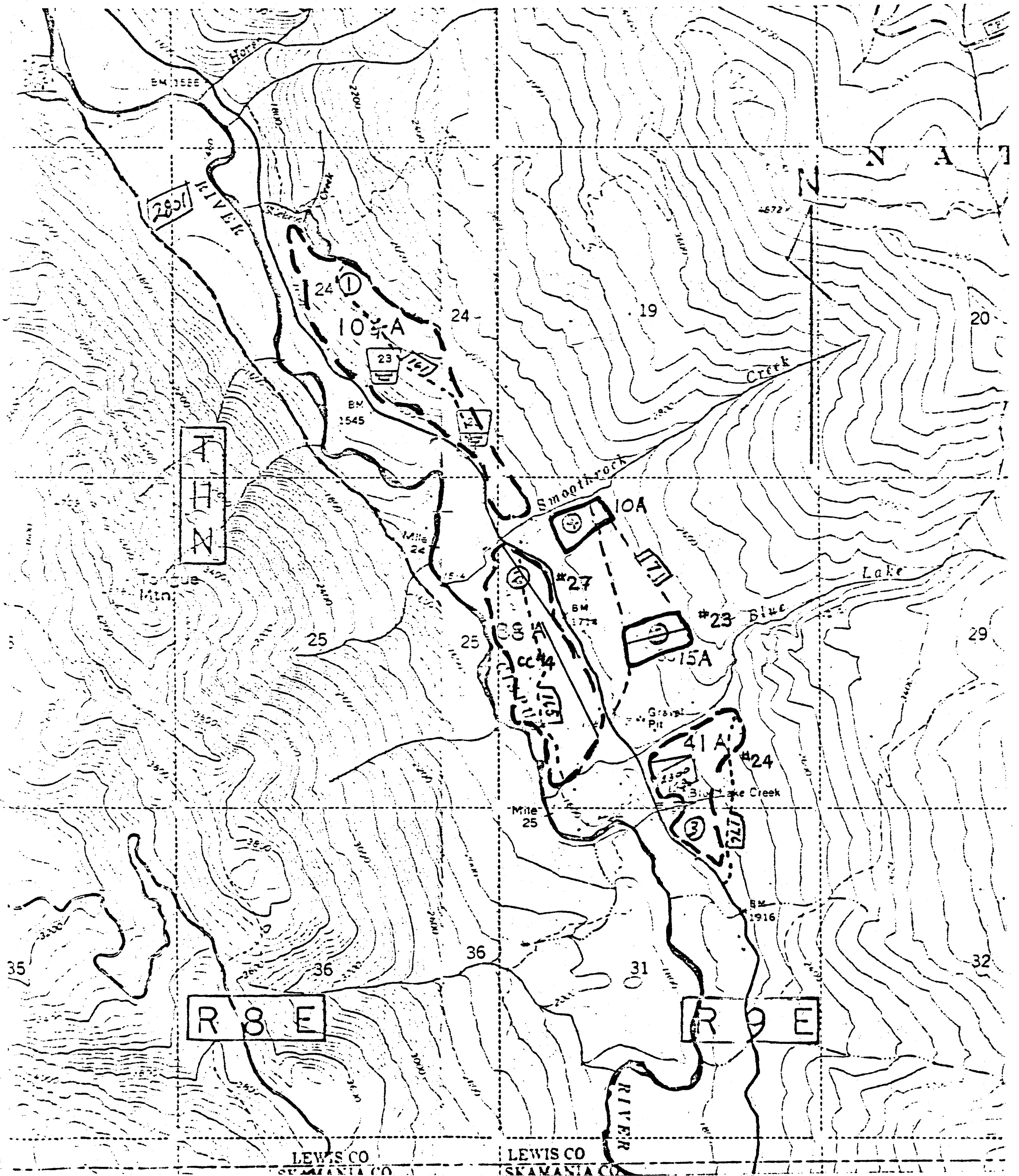
JUNIPER A TIMBER SALE
356A HTH

1987



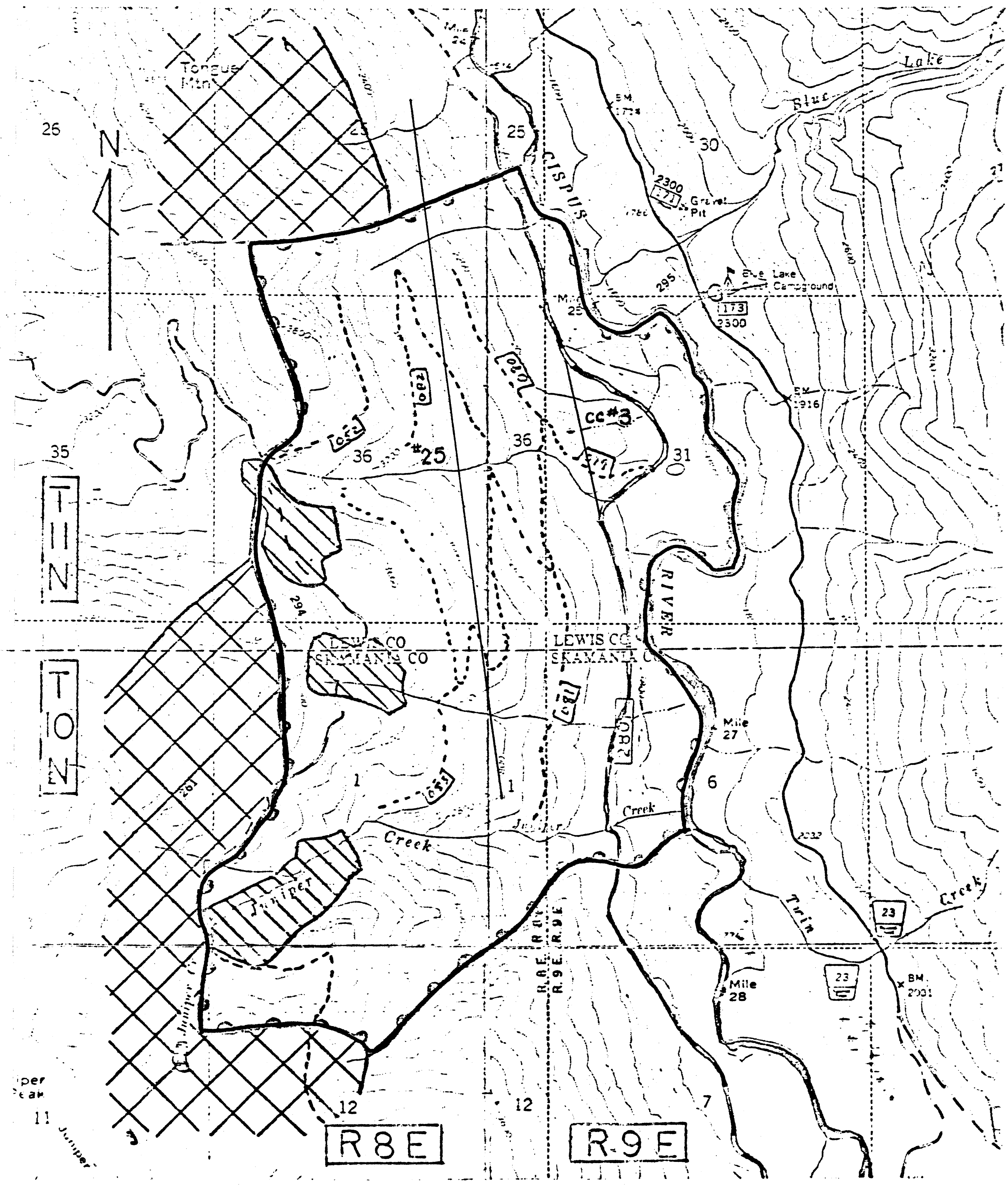
BISHOP B TIMBER SALE
233 A HTH
25 A HCC

1988



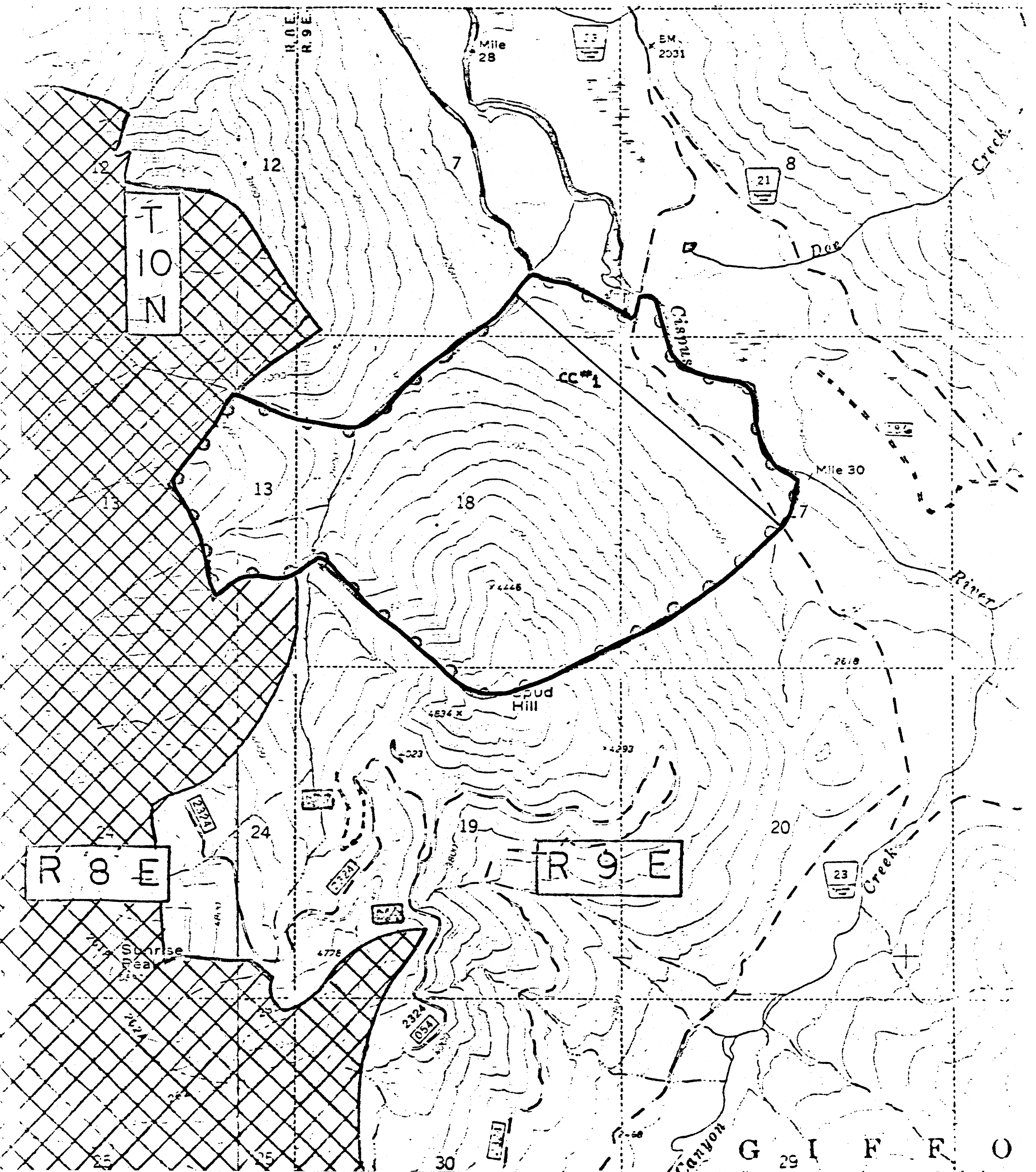
KIDD B PROJECT AREA

1988



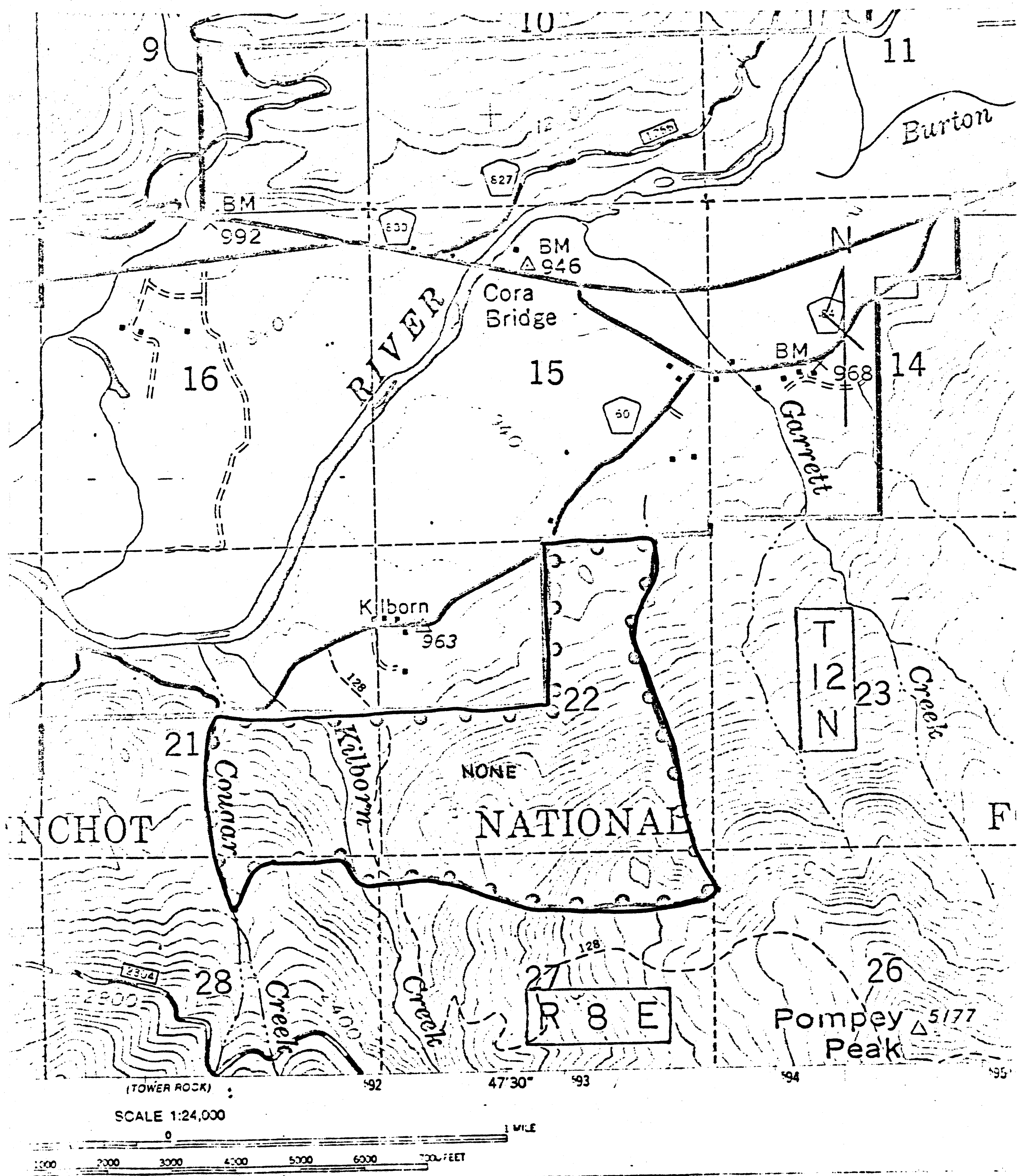
SPUD A PROJECT AREA

1990



POLK K PROJECT AREA

1992



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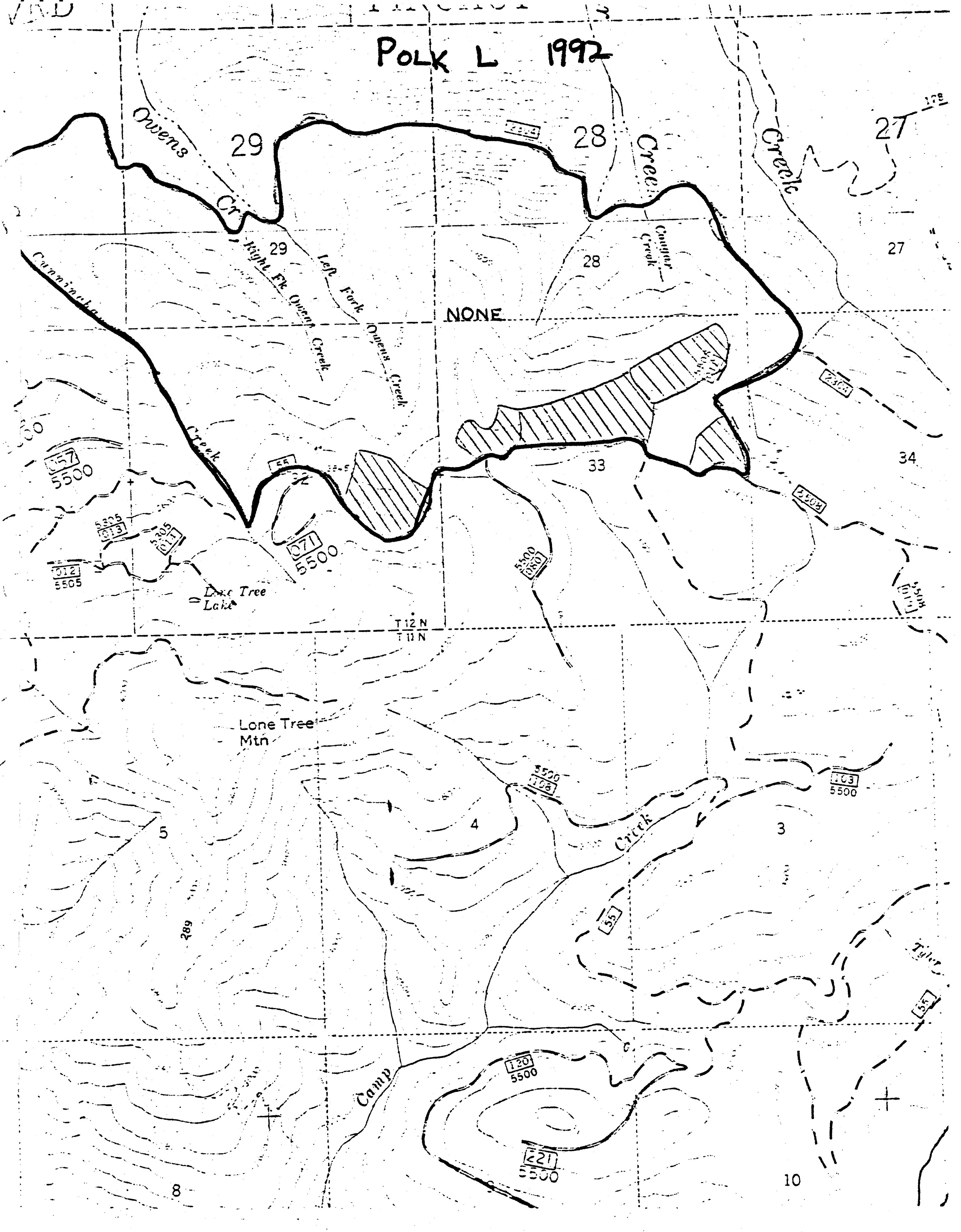

POLK L 1992
Owens
Cr
29
28
Creek
Creek
27
29
Right Fk Owens Creek
Left Fork Owens Creek
28
Cougar Creek
27
NONE
Creek
057
5500
55
32
33
34
5508
5305
013
012
5505
071
5500
5500
080
Lone Tree
Lake
T 12 N
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Lone Tree
Mtn
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5
4
Creek
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289
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120
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Camp
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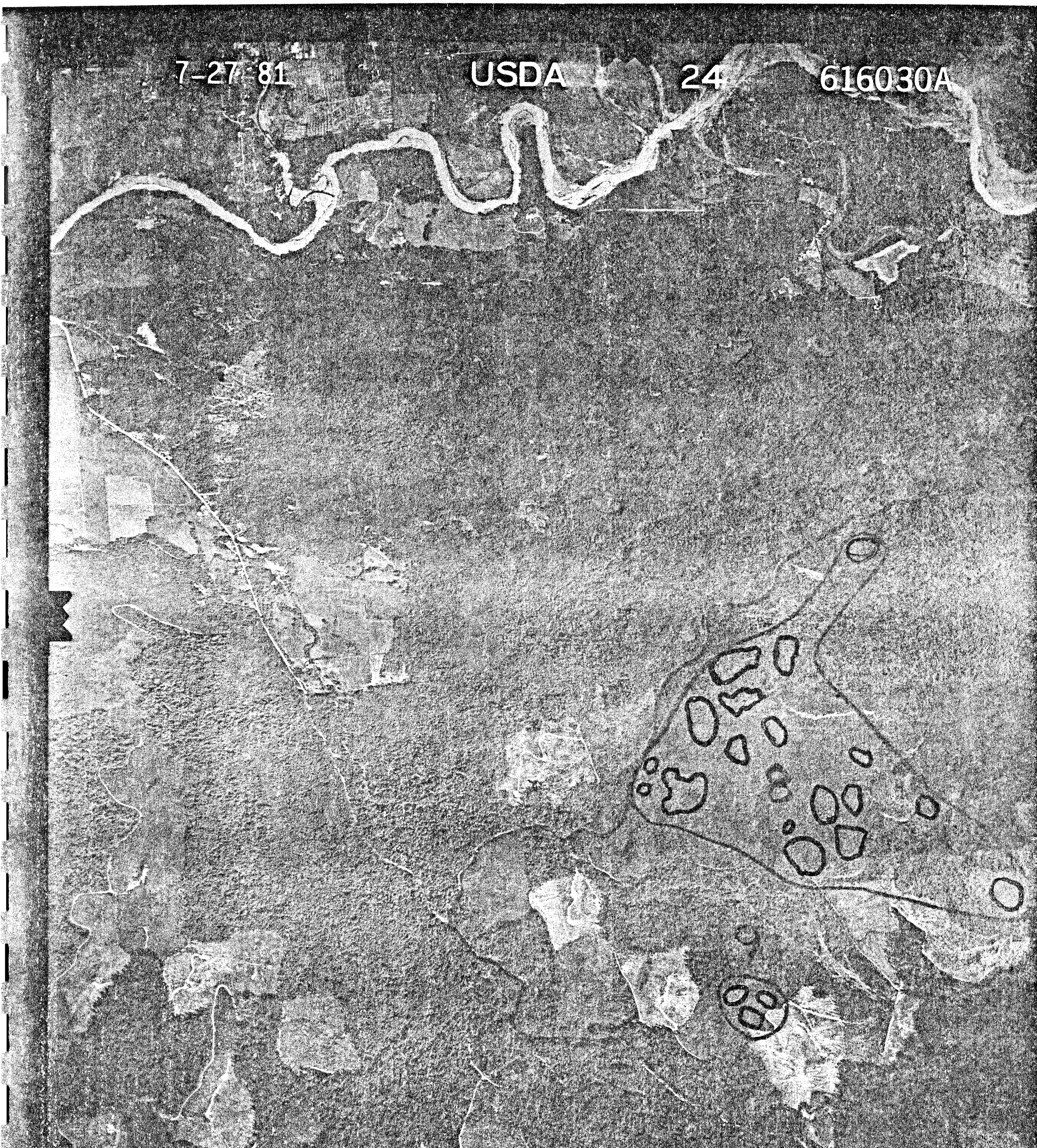
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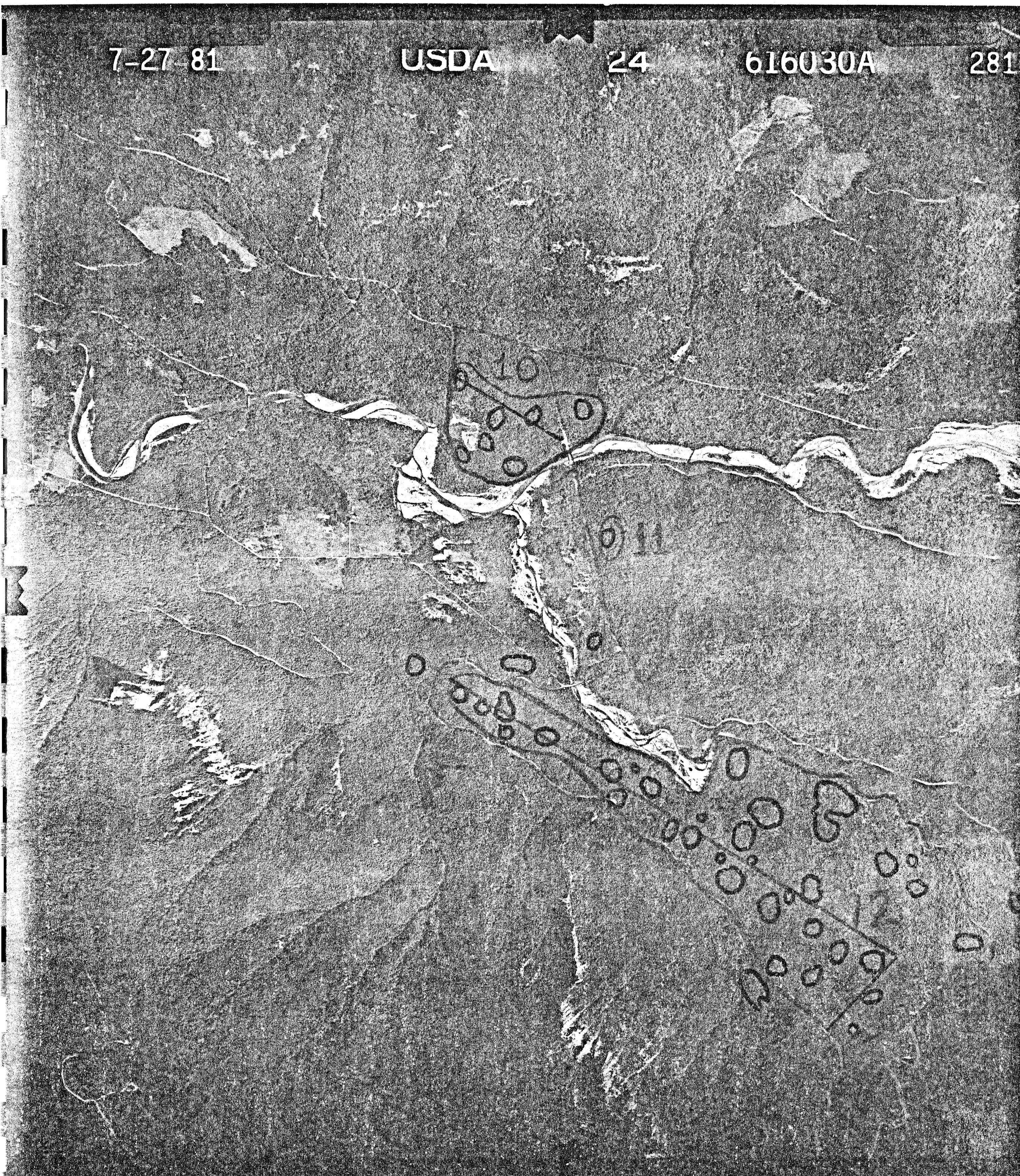
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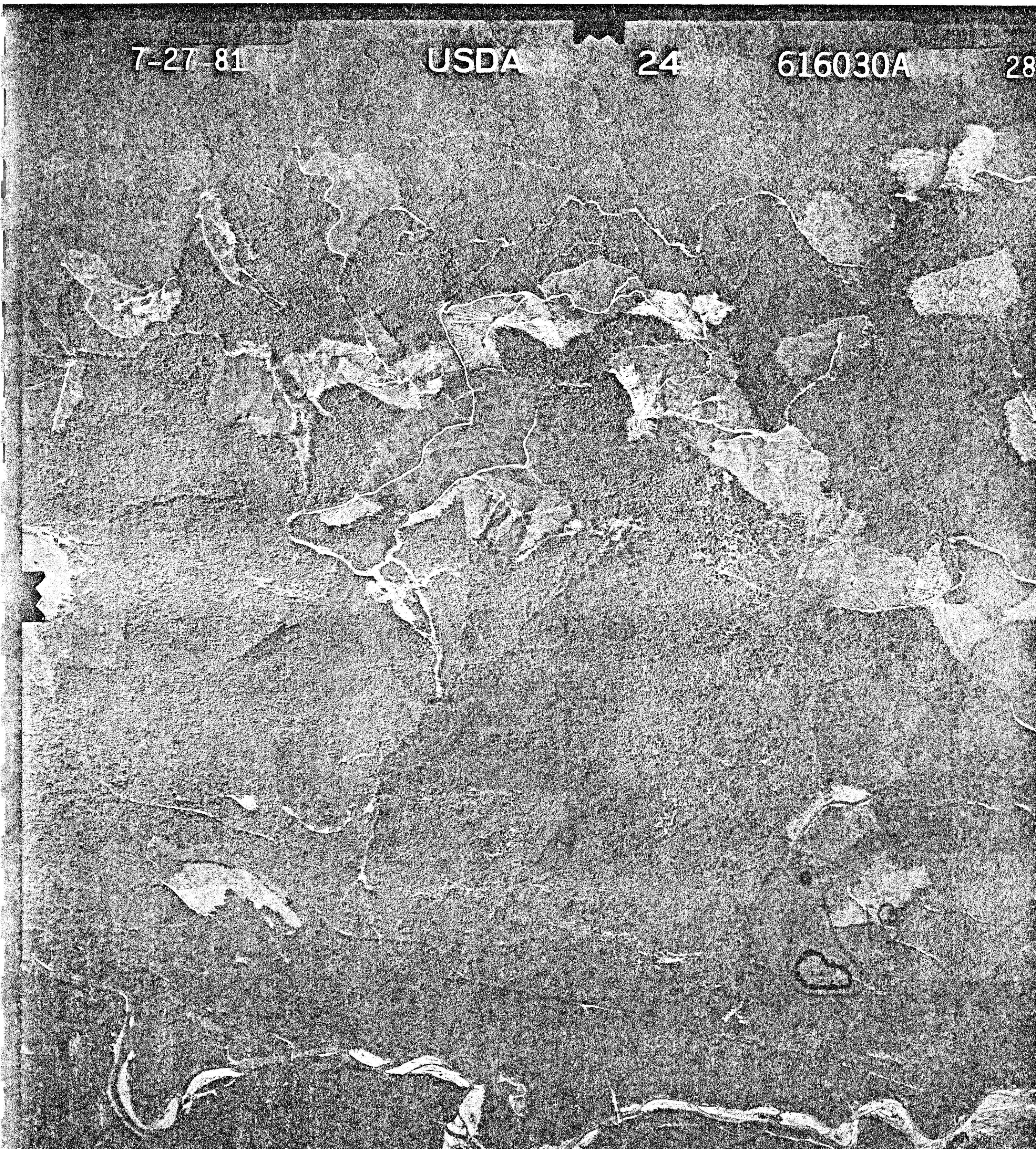
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28
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22
21
CC#A
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CC#B
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24